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**The Design and Production of new  
Retirement Savings Products:  
A Note**

**Research Memorandum 2002-33**

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# **The Design and Production of new Retirement Savings Products: A Note**

**Research Memorandum 2002-33**

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The Design and Production of New Retirement Savings Products: A Note

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Introduction and summary

With the population in the U.S. and other countries ageing rapidly, the burden of future pension liabilities is ever increasing. In recent years, governments and companies have become much more aware of the inherent risks that are involved. As a consequence, there is a worldwide tendency to shift from defined benefit pension plans to defined contribution plans. The implications for employees are far-reaching: under a defined contribution plan, the employee bears the investment risk: the level of his pension depends on the return on his investments. Under a defined benefit system, the level of pensions is fixed and the sponsor (in many cases the employer) bears the investment risk: the premiums required to fund the pension depend on the return on investments. In this journal, Bodie and Crane (1999) (BC) recognize that the transfer of investment risk from employer to employee calls for easy-to-implement investment strategies that correctly reflect the trade-off between the risk of a poor pension and the joy of a sumptuous pension. They compare investments in traditional equity and bonds with investments in TIPS (inflation linked bonds) and equity with a protective floor. Their results suggest that a series of investments in a product with a protective floor have a much higher chance of reaching a specified retirement income level than investments in a mixture of equity and fixed income securities.

We replicated their analyses but obtain different results: based on their simulation framework, the protective floor strategies do not compare favorably to traditional investment policies. Whether one should prefer a protective floor strategy or a traditional equity and bonds strategy largely depends on the choice of risk-reward framework and prevailing market data.

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**Bodie and Crane: setup and risk-return framework**

BC analyze the performance of alternative investment strategies in a **simple** and **appealing** defined contribution framework. They **focus** on a hypothetical employee, aged 25, **who still** has 40 years of employment to **come**. At the end of **each** year, he invests a **fixed** percentage of wages in a retirement income fund. In the **final** year of employment, the hypothetical worker earns USD 50,000; his target retirement income equals 60% of his **final** wage, **or** USD 30,000. During the years of employment, wages are supposed to rise at the **rate** of inflation. The question is **how** the employee should **invest** his periodic pension contributions.

Investment Opportunities	return assumptions	
TIPS	total return ( $\mu$ )	: 10%
<b>S&amp;P</b> 500 index	dividend yield (q)	: 3%
One-Year Protective Floor	<b>volatility</b> ( $\sigma$ )	: 20%
Five-Year Protective Floor	inflation	: 4%
	<b>nominal interest rate</b>	: 7%

Table 1: investment opportunities *and* the assumptions on their returns.

BC evaluate various investment strategies using two criteria: expected pension and the probability of achieving a target pension. Table 1 **lists** their set of investment opportunities and the assumptions they make regarding their future returns. Table 2 shows the **main** results reported in Bodie and Crane, in **terms** of risk and return at the retirement date.

Investment Strategy	Average Value (\$000)	% of Results Below Target
100% TIPS	\$446	0
100% <b>S&amp;P</b> 500	856	34.3
60% <b>S&amp;P</b> 500/ 40% TIPS	654	28.6
One-Year Floor	<b>581</b>	10.8
Five-Year Floor	950	11.6

Table 2: *Results* reported by Bodie and Crane

Based on the results in table 2, BC suggest that “avoiding the downside appears to have substantial **benefit**”. Relative to an investment in 100% equity, the **five-year** protective floor strategy results in a substantially **lower** probability of not meeting the income target, while yielding a **higher** expected retirement income. From table 2, it is not **difficult** to see that for virtually **every** traditional **asset** mix, there exists an **asset allocation involving** a protective floor **such** that both the expected pension and the probability of achieving the target pension are **higher**.

**What theory tells us**

Before we present **our** simulation results, we **provide** more intuition for the Bodie and Crane results by a **short analysis** of the protective floor strategies. We make two **simplifying** assumptions:

- Inflation is constant at 4%. It **can** easily be **checked** that, **given** the **low volatility** of inflation, this does not affect the outcome in a **material** way.
- **Instead of having** periodic investments, we **analyze** a five year buy and **hold** investment. Table 2 shows that the total expected return on **all** periodic investments in the **five** year protective floor strategy exceeds the total expected return on the 100% equity product. This implies that the expected return on a single payment of the protective floor strategy over **a five** year horizon **also** exceeds the expected return on a single payment of an equity investment over a **five** year horizon.

Assuming that **all** dividends on equity are immediately reinvested, a USD 100 investment in equity **grows** in expectation to USD 161.05 in **five** years. The expected return on the **five** year floor product **can also** be derived: In order to guarantee the **real value** of the initial investment, we need to **invest**

$$\frac{100}{(1 + 3\%)^5} = 86.26.$$

in TIPS. The remainder,  $100 - 86.26 = 13.74$ , **can** be invested in **call** options on the **S&P** 500 index. **Given** the simulation framework of BC, the **call** options should have a strike equal to

$100 \times (1 + 4\%)^5 = 121.67.$

The Black-Scholes price of this option is 15.37, which leads to a participation rate of

$\frac{13.74}{15.37} = 0.894$

BC also report this participation rate. The expected final value of this option can be computed analytically<sup>6</sup>. Given an expected total return on the S&P 500 of 10% and a divided yield equal to 3%, the expected final value of the option equals 32.46. It follows that the expected final value of the portfolio of TIPS and call options is:

$121.67 + 0.894 \times 32.46 = 150.68.$

This corresponds to an annualized expected return of 8.5% • considerably less than the 10% on the S&P 500 index. To obtain an expected return equal to that of the S&P500, one has to buy 1.21 call options instead of 0.894. This is possible only if call options can be bought at less than 75% of their Black Scholes price. This result is clearly in conflict with BC who report an expected value for the five year protective floor strategy higher than the expected return on the S&P500 (table 2).

In table 3, we report simulation results consistent with the theoretical analysis above. There is a marked difference with the results in Bodie and Crane, reported in table 2. The most important outcome is that relative to 100% equity, the expected pension of the five year protective floor strategy is lower. In terms of risk, the two strategies look more similar now.

Investment Strategy	Average Value (\$000)	% of Results Below Target
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<sup>6</sup> Using the Black-Scholes assumptions, it is easy to derive the following expression for the expected value C of a call option with strike K, time to expiry T, volatility σ and continuous dividend yield q:

$$C = e^{(\mu - q)T} \Phi(d_1) - K \Phi(d_2),$$
$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(\mu - q + \frac{1}{2}\sigma^2\right)T}{\sigma\sqrt{T}},$$
$$d_2 = d_1 - \sigma\sqrt{T}.$$

100% TIPS	\$446	0
100% S&P 500	853	34.8
60% S&P 500/ 40% TIPS	654	29.0
One-Year Floor	519	29.0
Five-Year Floor	659	34.3

Table 3: Our simulation results

### Concluding remarks

We have shown analytically that, **contrary** to what the BC resuhs suggest, protective floor strategies do not yield **higher** expected returns than pure equity investments. This theoretical **result** is corroborated by our simulation results, which have been obtained by replicating the BC simulations. As protective floor products do not **result** in a **higher chance** of reaching a target retirement **income level** either, the BC simulation results do not suggest that there is a lot of potential for these products in defined-contribution **plans**.

It is important to **notice** though that this **result** only applies to the **specific** protective floor strategies developed in BC in combination with the **specific risk -** return framework **chosen** by BC. **Indeed**, it has been shown that **well chosen** option strategies are superior to traditional investments in a **variety** of risk-return frameworks (see e.g. Carr and **Madan** (2001)).

Moreover, in a setting of DC pension investments “peace of **mind**” **can** be a valuable **asset** in its own right and protective floor strategies arguably score **well** on this criterion.

### References

Bodie, Zvi and Dwight B. Crane (1999), “The Design and Production of New Retirement Savings Products”, The Journal of Portfolio Management, Vol. 25(2), pp 77-82.

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